INSTRUCTION MANUAL

FOR

Model 2 Geiger Counter
Model 3 Geiger Counter

1/15/72

CIRCUIT THEORY OF OPERATION

Description:

The instrument consists of five major operating circuits: amplifier, discriminator, ratemeter, speaker driver and high voltage power supply.

AMPLIFIER: The amplifier consists of four (4) transistors with overall feed back stabilization. By using "operational" amplifier techniques in feedback, the amplifier maintains very stable input impedance and gain characteristics for large variations in supply voltage and temperature.

The first transistor (Q1) is an emitter follower, giving the stage a high input impedance. The second transistor (Q2) is the amplifier transistor. It uses a PNP transistor (Q4) as a constant current load, resulting in a very high open loop gain. A low impedance output is accomplished by emitter follower Q3. Bias stabilization is provided by a low value D.C. resistance connection from output to input (R6, R7). This bias feedback circuit is bypassed to ground by a capacitor (C2), allowing the high impedance feedback element (R8) to be effective for the signal frequencies. Amplifier gain is controlled by the ratio of (R1) to (R8).

DISCRIMINATOR: The amplifier is coupled through C3-R9 to a tunnel diode discriminator (CR2, Q5). During the quiescent state, CR2 exhibits extremely low impedance and essentially shorts the Q5 base to emitter cutting Q5 off. For a pulse amplitude such that R9-CR2 current exceeds 1.0 milliamphere; CR2 shifts to a low conductance state and Q5 saturates. This condition is maintained until the diode current drops to approximately 0.1 milliamphere. With Q5 saturated, Q6 saturates and a positive pluse is developed across R12, R13.

RATE METER: The rate meter circuit consists of univibrator Q7, Q8 and meter driver Q10 and Q11.

In the quiescent state Q8 is saturated by R16. This holds Q7 and Q10 cut off through R18 and R19 respectfully.

When a positive pluse is developed across R13, this saturates Q7 causing Q8 to cut off, holding Q7 in saturation through R18 until the charge on the time constant capacitor (C7 through C10) drains off. Then Q8 saturates, cutting off Q7 and the quiescent condition returns.

CR7 prevents Q7 from cutting off prematurely by the decay of the pulse across R13. R14 discharges C4 preventing a charge buildup. With Q8 cut off, Q10 is saturated, allowing current to flow from the battery through C11, CR6, Q10 and constant current generator Q11, then through limiting resistor R24 and calibration potentiometers to ground.

Q11 is biased as a constant current generator by diode CR4 and the current through Q11 is controlled by the total resistance from the emitter of Q11 to ground. (I.e. calibration controls)

All this causes a charge build up on C11 which drains off through the meter, with the meter current being proportional to the average count rate.

SPEAKER DRIVE: The speaker is a piezioelectric unimorph element and is driven at the resonate frequency by blocking oscillator Q14, T2. Loudness and frequency may be controlled by the audio chamber or by R30. With the emittor of Q14 connected to a positive supply voltage, Q14, T2, and associated components oscillate spontaneously, driving the unimorph.

In practice, voltage to Q14 is cut off by Q13 (cut off) and Q12 (cut off).

Q12 is held cut off by R26 or R25. However, when Q8 is cut off by the discriminator, Q12 is saturated through R25, which causes Q13 to saturate, supplying voltage to Q14.

Also, when Q13 saturates, Q12 is held in saturation by R27, C12 until the residual charge on C12 is depleted. This stretches the short pulse on the univibrator to a reasonable audio pulse.

This circuit does not draw idling current except leakage current through Q13, though this is held to a minimum by R29.

DETECTOR HIGH VOLTAGE POWER SUPPLY: The high voltage supply consists of blocking oscillator type high voltage generator Q22, T1, CR8—CR10 and voltage regulator Q15 through Q21 and associated components.
The high voltage generator utilizes a conventional blocking oscillator Q22, T1 and voltage quadrupler CR8 through CR11.

The blocking oscillator frequency (and resulting high voltage output) is controlled by bias resistor R42. Lowering the value of R42 causes output voltage to increase until a critical point is reached, where the oscillator saturates (usually causing Q22 to fail). C15 also has limited effect on the output, with a minimum charge storing capacity required. R43 and C14 act as a low pass filter in the base feed back, preventing secondary oscillations in the transformer circuit.

Q15 through Q18 functions as a DC amplifier, with the basic bias level established by constant current generator Q17 (as controlled by CR7, R39). With no voltage output, Q15 is cut off by R32 to ground (through temperature compensation transistors Q20, Q21, connected as diodes and limiting resistor R31). With Q15 cut off, Q16 is cut off, Q18 is saturated by Q17 and Q19 is saturated by Q18, causing minimum resistance to be presented through R42 to the blocking oscillator.

Assuming the oscillator is working, high voltage will develop across filter capacitor C20 and be fed back to the reference amplifier through R33, R34, R35 and R36. This in turn brings Q15 and Q16 into conduction, causing Q18 to decrease conductance and Q19 collector current to decrease (with apparent higher resistance through R42). In that Q17 is independently biased for a constant current output, the amplifier will stabilize at the point where the base emitter voltage of Q16 plus base emitter voltage of Q15 is just enough to allow the Q16 collector to conduct the constant current from Q17. In essence, Vbe (Q15) + Vbe (Q16) = i (Q17) becomes the high voltage reference voltage. This is the voltage present at the base of Q15 relative to ground.

As battery voltage, output load or setting of R32 is changed, the reference amplifier will increase or decrease the conductance of Q19 so that the high voltage source voltage through R33-R36 will maintain Vbe (Q15) at a constant value.

Decreasing R32 will cause increased high voltage. Increasing R32 will lower voltage.

MODEL 2 and 3 GEIGER COUNTER

NOTE 1: The Model 3 is identical to Model 2 only is supplied with four (4) counting scales.

NOTE 2: Many instruments are supplied with special counting scales. See the notes on cover sheet for this specific instrument.

Preparing Instrument For Operation:

1. Slide battery box button to rear, open lid and install two "D" size batteries. Note (+) (—) marks on inside of lid. Match battery polarity to these marks.

   NOTE: Center post of flashlight battery is positive

   DO NOT TWIST LID BUTTON—It slides to rear

   Close battery box lid.

2. Swith Range Switch to BAT. Meter should deflect to the battery OK portion of the meter scale. If meter does not respond, recheck that batteries have proper polarity.
3. Connect cable to instrument and detector.
4. Turn instrument range switch to X10. Expose detector to check source. Speaker should click with Audio ON —OFF switched to Audio ON.
5. Move range to lower scales until meter reading is indicated. Toggle switch labeled F-S should have fast response in F, slow response in S.
6. Depress RES switch. Meter should zero.
7. Check calibration and proceed to use the instrument.

Instrument Fundamentals:

The Model 2 is a three scale, self-contained geiger counter. The instrument is calibrated to Radium 226.

This instrument is set for 900 volt GM tube operation and may be supplied with an assortment of GM tubes. For special requirements, the detector voltage may be internally adjusted for operation with any GM tube between 400 and 1500 volts, Alpha scintillators or high energy Gamma scintillators.

The unit is battery operated with two flashlight batteries (carbon zinc) for operation from 150° to approximately 32°F.

For lower temperature operation, either very fresh (never used carbon zinc batteries or rechargeable NiCd batteries may be used. Battery drain averages 12 milliamphere.

The audio utilizes a piezoelectric crystal mounted to the instrument can. If an extremely noisy environment is encountered, a special hearing aid accessory worn in the ear can be supplied to aid aural monitoring.

Description of Controls:

PANEL CONTROL

Range Switch: A five position control that turns the instrument on, checks battery, and selects the counting range. The red mark exposed indicates that the instrument is on. Turn the range switch fully counter clockwise for off. (Cover the red mark.)

Multiply the meter reading by the multiplier X0.1-X10 for the scaled meter reading.

CALIBRATION CONTROLS

On line with each multiplier position is a 1/8" hole with recessed control. These controls allow individual calibration for each range. Adjust with a 1/8" blade screwdriver.

RESET

Push button labeled RES. Depress to allow rapid discharge of meter after over scale deflection.

AUDIO ON—OFF

Turns audio off when not required. Reduces battery drain as well as noise fatigue.

RESPONSE

Toggle switch labled F-S. Set on F for fast response, and large meter deviation. Set on S for slow response and damped meter deviation.

INTERNAL CONTROLS

One unlabeled internal control for adjusting detector operating voltage. This control is normally set for 900 volts.

CALIBRATION

1. DETECTOR OPERATING POINT: Remove instrument housing from can by loosening two screws in can bottom. Install batteries and connect an electrostatic voltmeter to the connector center conductor, Adjust the high voltage control located on the circuit board for 900 volts output.

NOTE: If an electrostatic voltmeter is not available, use an ordinary volt-ohm-milliameter (Triplett 630 or equal) with 20,000 ohms per volt meter resistance. Adjust to 6,000 volt scale and then adjust high voltage to read 850 volts on this scale. (For more exact adjustment, the output

impedance of the power supply is 1 megohm. Find input impedance of voltmeter, not less than 100 megohms, and adjust accordingly.)

Do not use a vacuum tube type voltmeter for this adjustment unless an external high voltage multiplier probe is used.

2. After adjusting high voltage, replace instrument housing.
3. Install fresh batteries and turn instrument to X10. Expose the instrument to a calibrated gamma field and adjust calibration control for proper reading.
4. Repeat above procedure for other scales.

Special Use Calibration:

The above calibration procedure is for probes.
For special applications, the power supply may be adjusted for 450 volt and 1200 volt GM tubes. Follow above procedure only set the supply at the new operating voltage. Under this case, the internal detector should be removed, disabling the X100 scale.

For scintillation counters, connect the scintillator. Expose the unit to a source and develop an operating voltage versus count rate plot. Set the operating voltage at the flattest portion of this curve, then proceed to adjust each calibration control for the desired meter reading.

BILL OF MATERIAL

R1-R3*	500 ohm Log Taper Potentiometer Allen-Bradley WA2L404S501TC
R6	2.2K, ½ watt, 10% Composition
R7	18K, ½ watt, 10% Composition
R8	SAT for 2.2 volt Battery cut-off
B1/B2	Any "D" size battery with two cell voltage between 2.2 volts and 4.5 volts.
S1	Centralab, PA600-210
S3	SLOW-FAST: Alcoswitch #105-D
S4	AUDIO ON-OFF: Alcoswitch #105-D
S5	Grayhill #30-1 SPNO
M-1	Ludlum 62X4 Meter, 0-50 microamps taut band with waterproof case.

*Add R4 for Model 3

62X1	Circuit Board Complete
62X5	Battery Contact Assembly
62X15	Battery Lid Assembly
62X16	Chassis Assembly
62X17	Cover Assembly
62X9	Can Assembly
62X10	One set mounting hardware
UG706/U	External Detector Connector
62X18	S1 with harness
62X12	Meter Time Constant Board
Audio Transducer	Vernitron Model #P/N60690 Unimorph
62X13A	Unimorph Plug
62X13B	Unimorph Mounting Shell
62X13	Complete Unimorph with Shell and Plug

OVERHAUL

In event of instrument failure, check out following most probable causes:

1. Batteries: Press battery check and insure that batter have adequate output. If not, change batteries. Check for corrosion.
2. Cable and Detector: Try new cable and detector, or check cable continuity with ohm meter, both ground and center conductor.
3. Check for presence of high voltage on external detector.
4. Remove housing and trace out wiring for connection failure. Check that battery voltage gets to circuit board.

In the case that instrument failure is isolated to the circuit board, use a logical procedure to isolate the problems to the main circuit groups. The following hints may be helpful.

AUDIO:

(1) To check unimorph continuity, remove plug and touch a 22 volt battery across the unimorph leads. A slightly audible click or hiss should be heard.

(2) Tie the base of Q12 to battery voltage through a 10K resistor. A continuous tone should result.

HIGH VOLTAGE:

(1) Tie collector of Q19 to ground. Output of high voltage should jump to approximately 2000 volts. This isolates high voltage supply from regulator.

(2) Base to ground voltage at Q15 should be approximately 1.2 volts, and collector voltage of Q16 the same.

RATE METER:

(1) Clip base of Q8 to ground. Meter should go full scale very hard. Q7 should saturate.

(2) Check that emitter voltage of Q9 is in the range of 0.8 to 1.5 volts.

DISCRIMINATOR:

Tie junction of R9-C3 to +3 volts through a 1K resistor. Q5 and Q6 should both saturate.

AMPLIFIER:

(1) Q1 base to ground voltage should be approximately 1.2 volts. Same voltage emitter to ground on Q3.

(2) Connect junction of R1-C1 to ground. Emittor voltage of Q3 should jump postive. Connect this junction to +3 volts. Q3 should cut off.

MAINTENANCE

NOTE: Never store instrument over 30 days without removing batteries. Although this instrument will operate at very high ambient temperatures, battery seal failure can occur at temperatures as low as 100°F. Neglected battery seal failure will surely cause one awful mess!

Instrument maintenance consists of keeping the instrument clean, periodic battery maintenance and calibration check.

It is recommended that automatic recalibration not be used with this instrument. The instrument design is quite redundant and once initial calibration is performed, recalibration should not be required if batteries are maintained in good condition.

None the less, an instrument calibration check should be performed every three months by exposing the detector to a known source and confirming proper reading on each scale.

Also at three month intervals, the batteries should be removed and the battery contacts cleaned of any corrosion. If the instrument has been exposed to very dusty or corrosive atmosphere, more frequent battery servicing should be used.

Use a spanner wrench to unscrew battery contact insulator, exposing internal contacts and battery spring. Removing the handle will facilitate access to these contacts.

CIRCUIT BOARD COMPONENTS

RESISTORS: All ½w 10% composition unless otherwise indicated.

R 1	22K	R16	6.8K	R31	SAT*
R 2	1K	R17	1K	R32	200K*
R 3	12K	R18	3.3K	R33	100 meg*
R 4	470 ohm	R19	1K	R34	100 meg*
R 5	1K	R20	22K	R35	100 meg*
R 6	56K	R21	10 ohm	R36	100 meg*
R 7	10K	R22	47K	R37	10 meg*
R 8	1 meg	R23	2.7K	R38	12K
R 9	390 ohm	R24	10 ohm	R39	470 ohm
R10	560 ohm	R25	4.7K	R40	10K
R11	560 ohm	R26	100K	R41	10K
R12	1K	R27	15K	R42	1.5K
R13	10K	R28	1K	R43	270 ohm
R14	10K	R29	1K	R44	10 meg*
R15	1K	R30	560	R45	1 meg

*R31 selected to limit output voltage
R32 Bourns Type 3359P-1 200K Potentiometer
RC-1 Consists of R33/34/35/36/37 and 321
R44 is 10 meg ¼w 10% Composition

TRANSISTORS:

Q1	2N3390	Q 9	2N1302	Q17	2N414	ECG100
Q2	2N1302	Q10	2N2713	Q18	2N1302	ECG 101 or 10.
Q3	2N1302	Q11	2N1302	Q19	2N2713	
Q4	2N1414	Q12	2N2713	Q20	2N2713	
Q5	2N1302	Q13	2N414	Q21	2N2713	
Q6	~~2N4250~~ MPS 6534	Q14	2N414	Q22	2N414	
Q7	2N2713	Q15	2N3390			
Q8	2N1302	Q16	2N2713			

DIODES:

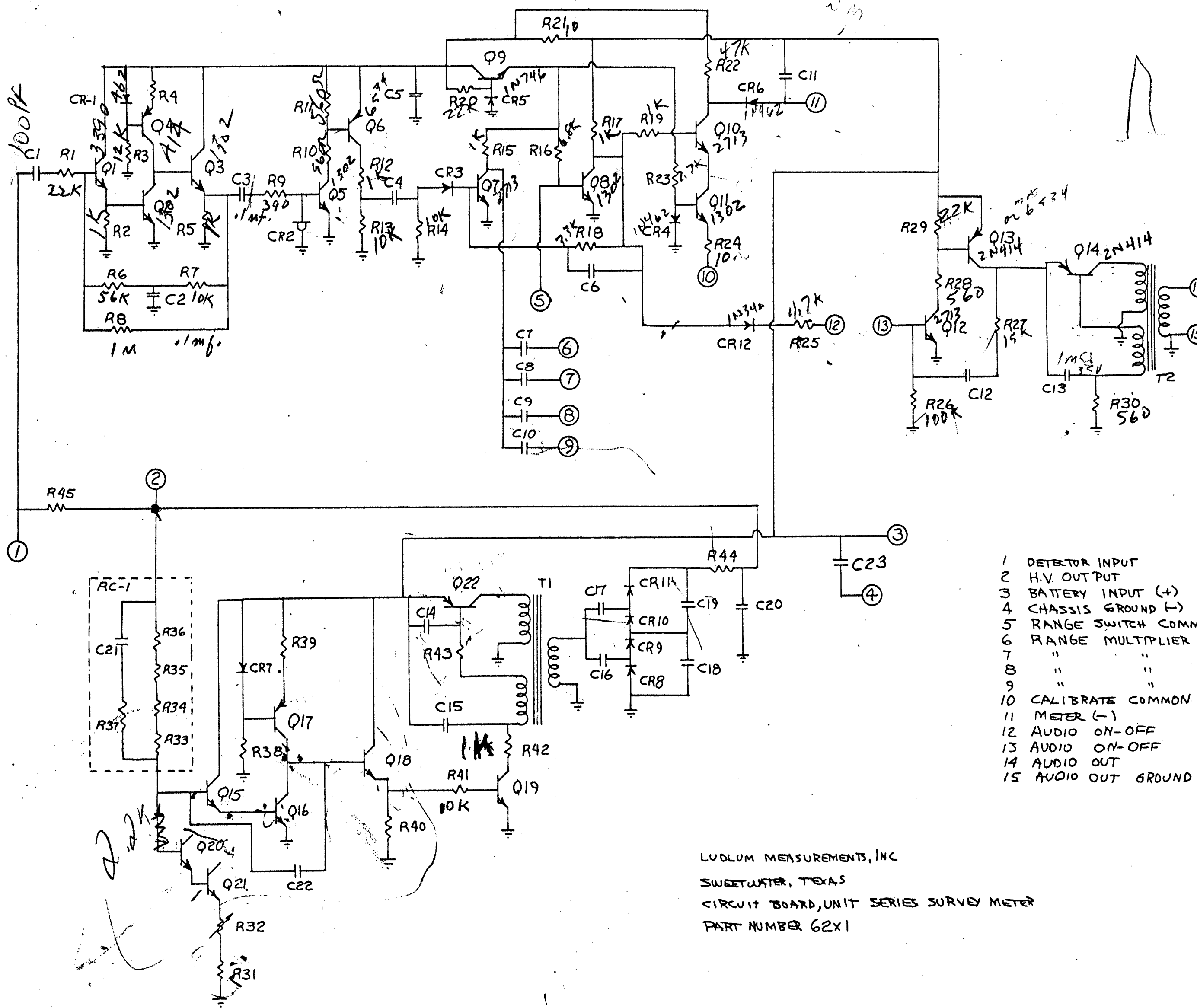
CR1	1N462	CR5	1N746	CR 9	~~1N4005~~ MR991A
CR2	1N3712	CR6	1N462	CR10	1N4005 MR991A
CR3	1N34	CR7	1N462	CR11	1N4005 MR991A.
CR4	1N462	CR8	~~1N4005~~ MR991A	CR12	1N34

TRANSFORMERS:

T1	Ludlum 62 x 3	T2	Ludlum 62 x 4

CAPACITORS:

C 1	100 MMF +/— 10% 2.5KV Mica	Elmenco	VDM20-101K
C 2	0.1 MFD +/— 20% 35v Tantalum	Mallory	TAS-104M035P1A
C 3	0.1 MFD +/— 20% 10v Ceramic	Centralab	UK10-104
C 4	0.001 MFD +/— 20% 500v Ceramic	Centralab	2DDH61L102KAC
C 5	100 MFD +/— 20% 10v Tantalum	Mallory	TAS-107K010P1F
C 6	220 MMFD +/— 20% 500v Ceramic	Centralab	CE-221
C 7	0.001 MFD +/— 20% 500v Ceramic	Centralab	2DDH61L102KAS
C 8	0.01 MFD +/— 20% 100v Mylar	Cornell-Dub	WMF-1S1
C 9	0.1 MFD +/— 20% 35v Tantalum	Mallory	TAS-104M035P1A
C10	1.0 MFD +/— 20% 35v Tantalum	Mallory	TAS-105M035P0A
C11	100 MFD +/— 20% 10v Tantalum	Mallory	TAS-107K010P1F
C12	0.1 MFD +/— 20% 10v Ceramic	Centralab	UK10-104
C13	1.0 MFD +/— 20% 35v Tantalum	Mallory	TAS-105M035P0A
C14	0.1 MFD +/— 20% 35v Tantalum	Mallory	TAS-104M035P1A
C15	1.0 MFD +/— 20% 35v Tantalum	Mallory	TAS-105M035P0A
C16	0.001 MFD +/— 20% 3Kv Ceramic	Centralab	DD30-102
C17	0.001 MFD +/— 20% 3Kv Ceramic	Centralab	DD30-102
C18	0.001 MFD +/— 20% 3Kv Ceramic	Centralab	DD30-102
C19	0.001 MFD +/— 20% 3Kv Ceramic	Centralab	DD30-102
C20	0.01 MFD GMV 2000v Ceramic	Sprague	BLS-10
C21	100 MMFD +/— 20% 3Kv Ceramic	Centralab	DD30-101
C22	0.01 MFD +/— 20% 100v Mylar	Cornell-Dub	WMF-1S1

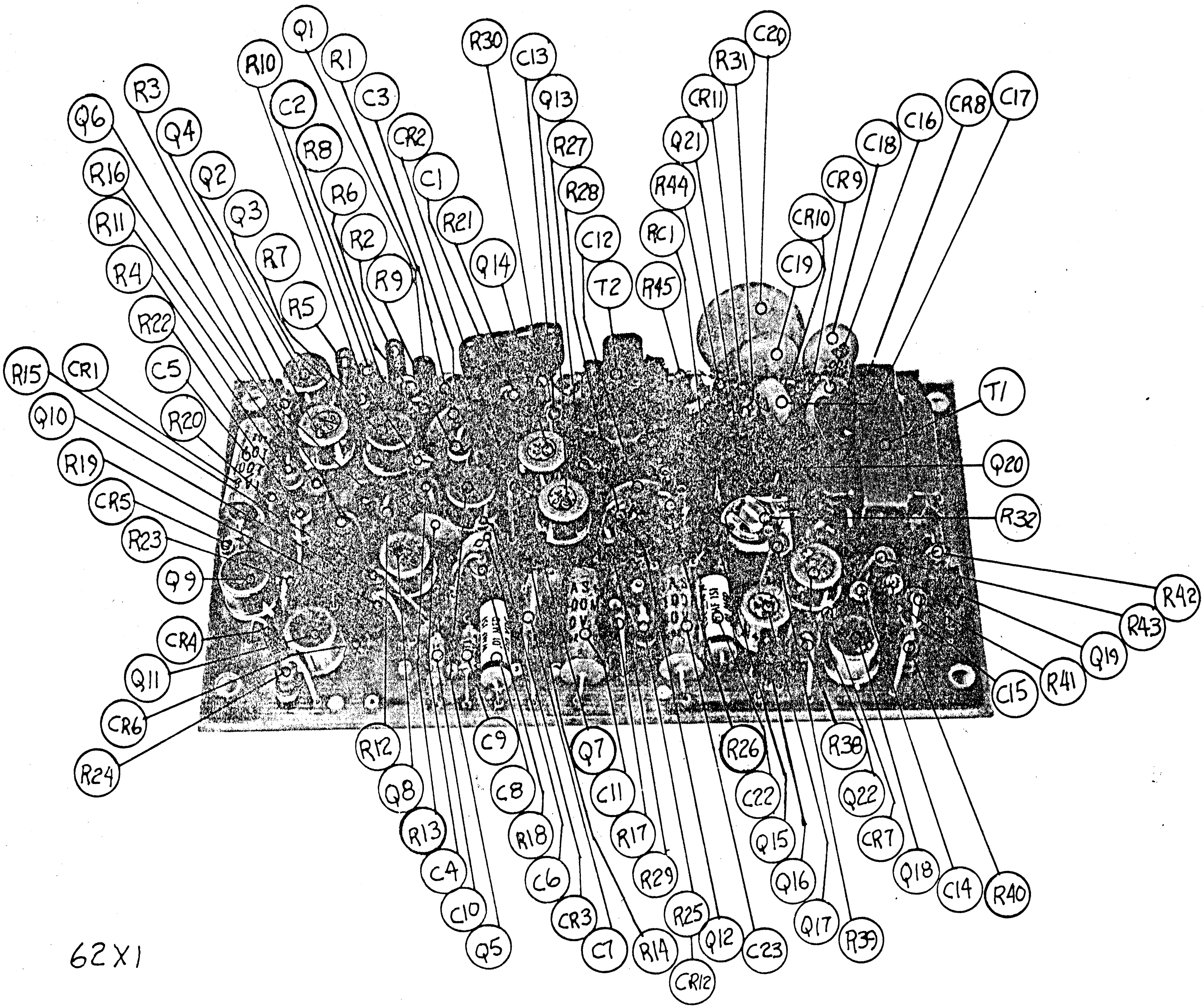


1302 emitter-tab side

1302
2N1010
10

1 DETECTOR INPUT
2 H.V. OUTPUT
3 BATTERY INPUT (+)
4 CHASSIS GROUND (-)
5 RANGE SWITCH COMMON
6 RANGE MULTIPLIER
7 " "
8 " "
9 " "
10 CALIBRATE COMMON
11 METER (-)
12 AUDIO ON-OFF
13 AUDIO ON-OFF
14 AUDIO OUT
15 AUDIO OUT GROUND

LUDLUM MEASUREMENTS, INC
SWEETWATER, TEXAS
CIRCUIT BOARD, UNIT SERIES SURVEY METER
PART NUMBER 62X1


Q1
R10
R1
C2
C3
R3
Q6
Q4
R8
CR2
R16
Q2
R6
C1
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Q3
R2
R21
R4
R7
R9
Q14
R22
R5
R15
CR1
C5
Q10
R20
R19
CR5
R23
Q9
CR4
Q11
CR6
R24
R30
C13
Q13
R27
R28
C12
T2
R45
RC1
R44
Q21
CR11
R31
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CR9
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CR12
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C11
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C8
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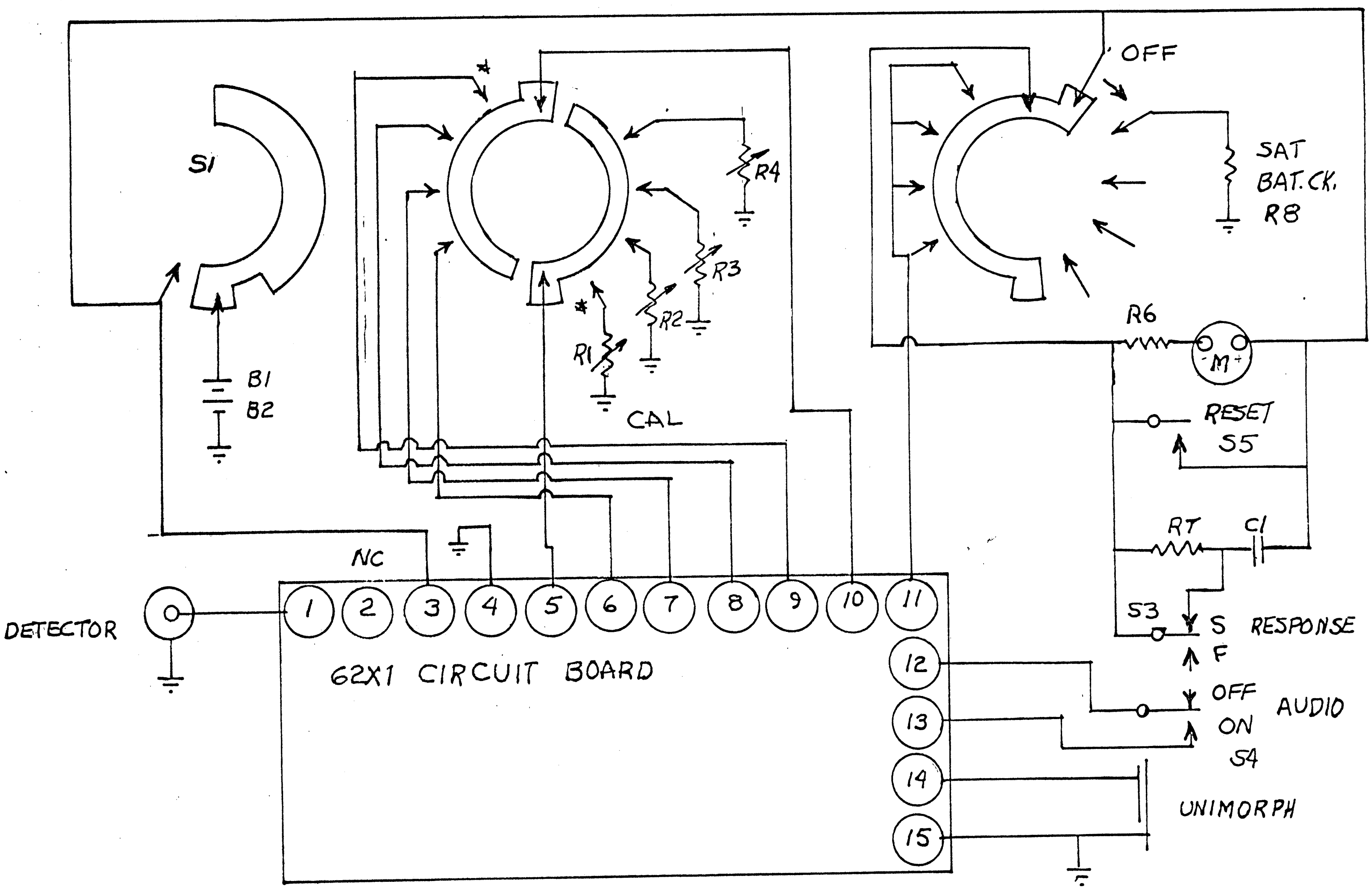
Q5
C10
C4
R13
Q8
R12

62X1



*MODEL 3 ONLY

GENERAL SCHEMATIC
MODEL 2, MODEL 3 GEIGER COUNTER
JAN 15, 1972 62X19